Space Weather Technical Forecast

Issued on Monday 6 January 2025 at 01:10 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: M-class flares expected, with an increased chance of X-class flares. Slight chance of a glancing CME late 6th or early 7th Jan, with a G1 Minor geomagnetic storm possible.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate with four M-class flares observed, all originating from AR3947 in the northeast of the visible disc. The largest flare events were two M4.1 flares occurring at 05/0239UTC and 05/0936 UTC.

There are ten sunspot regions on the visible disc. Despite the number of spots on the Earth facing-disc, many are small and generally magnetically simple. AR3947 in the northeast is the largest and most magnetically complex region. It has been responsible for the majority of recent activity, producing three lower X-class flares since rotating into view over the eastern limb. This region features several moderately sized spots, including a delta configuration within its intermediate spots, and has shown some development in its trailing spots in recent hours. AR3943, now approaching the central disc, has simplified recently as its forward spots continue to fade, which is now classified as a Hsx/alpha. In contrast, AR3945, trailing behind AR3943, has exhibited growth in its forward spots during the period. AR3939, though magnetically simple, generated two significant coronal mass ejections (CMEs) on 04 Jan but has since remained relatively stable. The remaining sunspot regions on the visible disc have shown either stability or slight signs of decay.

Two CMEs occurred from AR3939 in association with C-flares at 04/1444 and 04/1827. It is likely both of these CMEs will pass ahead of Earths orbit, however there is a slight chance that the latter CME may deliver a glancing blow late on Day 1 (06 Jan) or early on Day 2 (07 Jan).

Solar Wind / Geomagnetic Activity: Solar wind speeds observed by ACE at L1 were strong at 700km/s at the start of the period, but have since declined to elevated levels, currently near 550km/s. This is due to a connection with an high-speed stream from CH05/+. Density was below average levels. The Interplanetary Magnetic Field, Bt, has been weak to moderate, peaking at 9nT. The north-south component, Bz, fluctuated between negative and positive through much of the period, ranging between +7nT and -7nT. The Phi angle was mostly positive (away from the Sun).

Geomagnetic activity was mainly Unsettled to Active (Kp3-4) throughout the period.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) at GOES-18 breached the S1 Minor Storm threshold at 04/2215UTC in response to a C-flare from AR3939 at

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04/1827 UTC, peaking at 2.0pfu at 05/0555 UTC and declining below the S1 threshold at 05/0950 UTC.

High energy electron flux (greater than 2MeV) at GOES16 was at background to moderate levels with the associated 24 hr fluence well below Active. The 06/0000 UTC fluence observation was 1.88e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Activity is forecast to be Moderate to High, with further M-class flares expected and a chance of further isolated X-flares, mainly from AR3947 in the northeast.

Solar Wind / Geomagnetic Activity: There is a slight chance of a glancing blow from a CME later on Day 1 (06 Jan) or early on Day 2 (07 Jan), but it is more likely the CME will pass ahead of Earth's orbit. Earth's connection to a HSS associated with CH05/+ is expected to wane over the next few days. Elevated solar winds are likely to slowly decline on Day 1 (06 Jan), perhaps returning to background levels by Day 2 (07 Jan).

Geomagnetic conditions are expected to be mainly Quiet to Unsettled (Kp1-3) through the period, with a Slight Chance of a few Active or G1 Minor geomagnetic storm intervals (Kp4-5) initially in association with the HSS and also later Day 1 (06 Jan) or early Day 2 (07 Jan) if a glancing blow occurs from the aforementioned CME. Quiet to Unsettled conditions are expected on Days 3 and 4 (08-09 Jan) as CH HSS wane and possibly any lingering glancing CME effects.

Energetic Particles / Solar Radiation: GOES18 high energy proton flux has now decreased back below the S1 threshold after recent enhancement. There is a slight chance of further enhancement over the next few days should any further significant flares occur from the western hemisphere of the disc.

GOES16 high energy electron flux briefly reached High levels, with a peak flux of 1070pfu at 05/1950UTC, but soon declined to background. However, electron flux may rise to moderate or high levels later in the period as the influence of the HSS begins to wane. The associated fluence is expected to remain below the Active threshold, however there is a slight chance of exceeding the active threshold later in the period due to the risk of rising flux levels.

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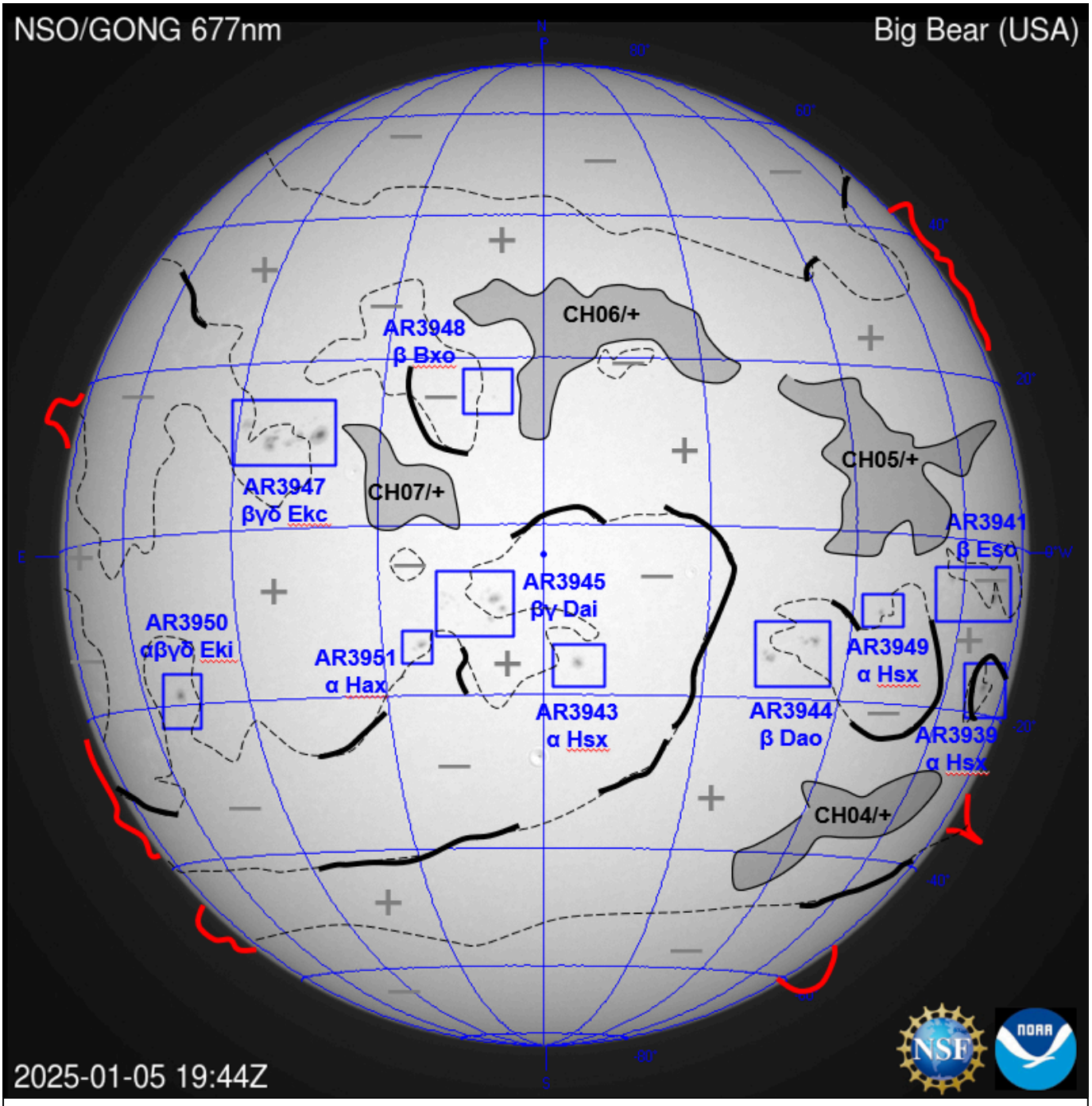
Figure 1: Solar map analysis - valid 05/1944 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

Two CMEs occurred from AR3939 in association with C-flares at 04/1444 and 04/1827. It is likely both of these CMEs will pass ahead of Earths orbit, however there is a slight chance that the latter CME may deliver a glancing blow late on Day 1 (06 Jan) or early on Day 2 (07 Jan).

Earth has been connected to a HSS associated with CH05/+ in the northwest of the solar disc since 04/1400UTC. This coronal hole was originally a larger hole consisting of CH05/+ and CH06/+ which has since been split into two CHs. Both coronal holes are persistent, although were smaller and further to the solar east on last rotation. Solar winds have been declining slowly over the past 12 hours and are expected to continue this decline over the coming days. Elevated to Slightly Elevated solar winds are likely on Day 1 (06 Jan), declining slowly into Day 2 (07 Jan), perhaps returning to background levels by Days 3 and 4 (07-08 Jan). It should be noted however that the density in the HSS is low and hence the resulting geomagnetic conditions are not expected to be significantly enhanced. MOSWOC ENLIL has the connection to the HSS too late, but its slow decline suggested following connection is accepted.

Geomagnetic conditions are expected to be mainly Quiet to Unsettled (Kp1-3) through the period, with a Slight Chance of a few Active or G1 Minor geomagnetic storm intervals (Kp4-5) initially in association with the HSS and also later Day 1 (06 Jan) or early Day 2 (07 Jan) if a glancing blow occurs from the aforementioned CME.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	No	20	20	1	1
Strong	**G3**	No	1	1	1	1
Severe	**G4**	No	1	1	1	1
Extreme	**G5**	No	1	1	1	1

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Figure 2: MOSWOC ENLIL shows a potential glancing CME either late on 06 Jan or early 07 Jan - mostly passing ahead of Earth's orbit.

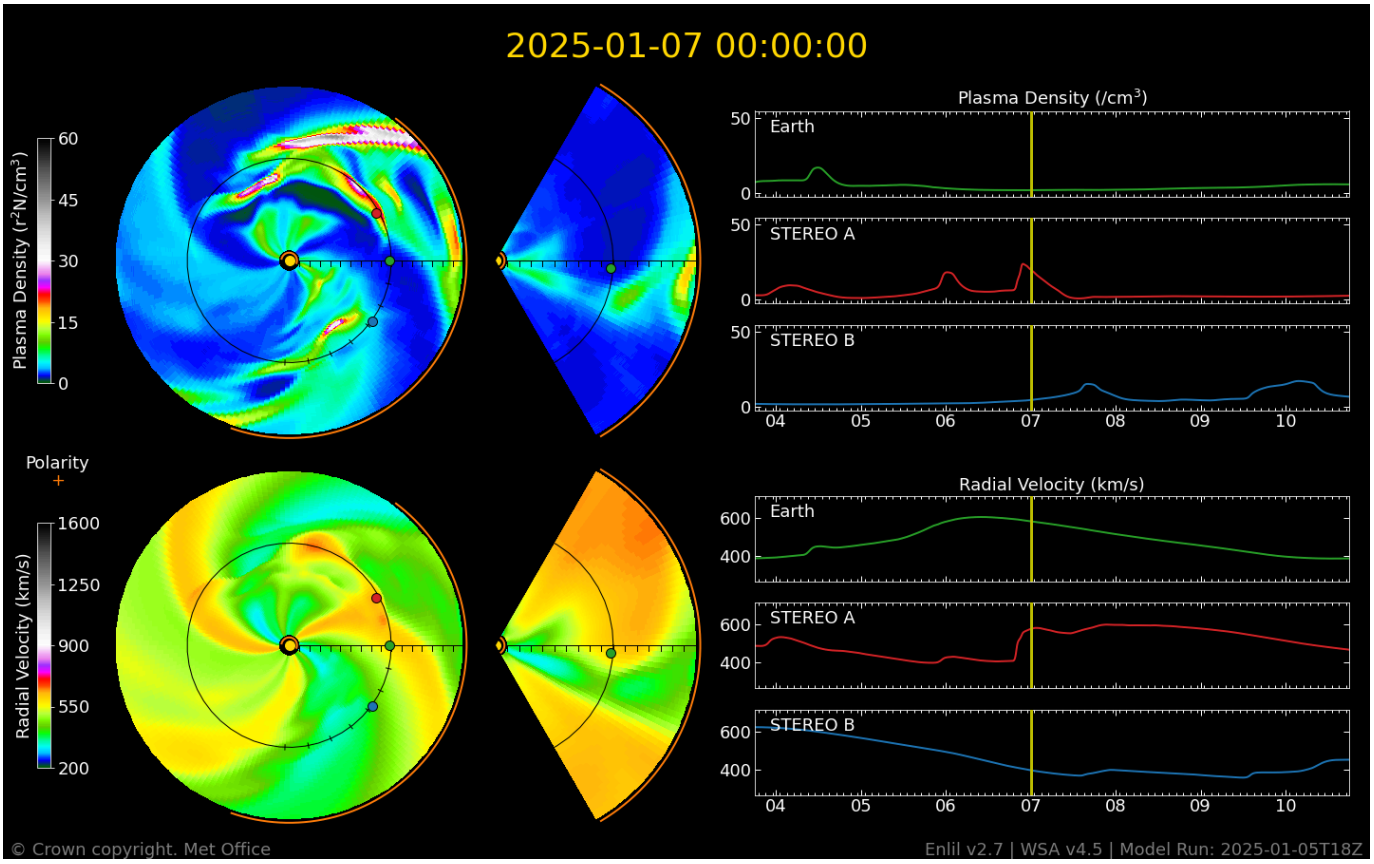

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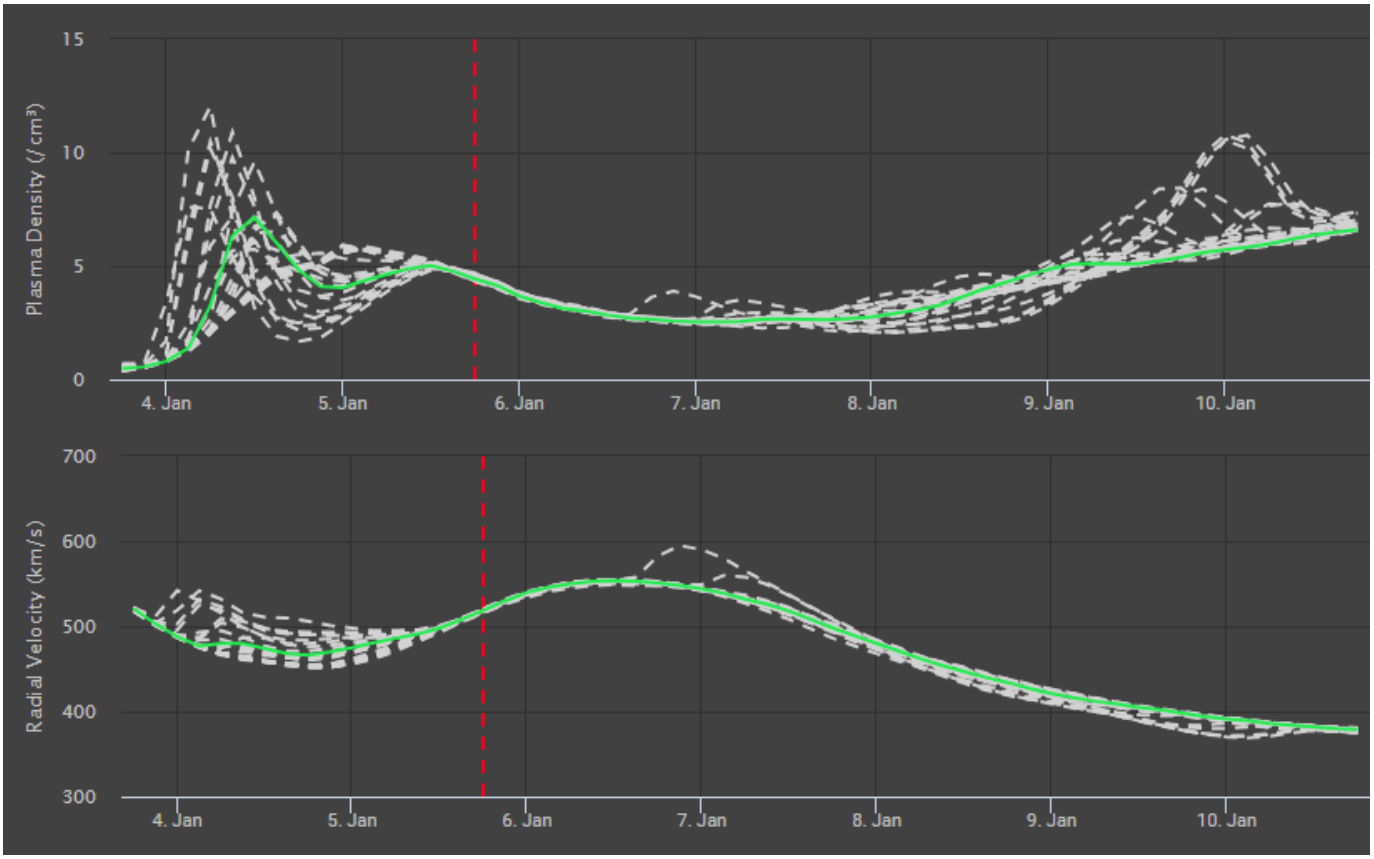
Figure 3: MOSWOC ENLIL ensemble - shows a possible glancing blow CME 06-07 Jan.



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Radio Blackouts - X-Ray Flares

Solar activity has been Moderate with four M-class flares observed, all originating from AR3947 in the northeast of the visible disc. The largest flare events were two M4.1 flares occurring at 05/0239UTC and 05/0936 UTC.

There are currently ten sunspot regions on the visible disc. Despite the number of spots on the Earth facing-disc, many are small and generally magnetically simple. AR3947 in the northeast is the largest and most magnetically complex region. It has been responsible for the majority of recent activity, producing three lower X-class flares since rotating into view over the eastern limb. This region features several moderately sized spots, including a delta configuration within its intermediate spots, and has shown some development in its trailing spots in recent hours. AR3943, now approaching the central disc, has simplified recently as its forward spots continue to fade, which is now classified as a Hsx/alpha. In contrast, AR3945, trailing behind AR3943, has exhibited growth in its forward spots during the period. AR3939, though magnetically simple, generated two significant coronal mass ejections (CMEs) on 04 Jan but has since remained relatively stable. Otherwise there has been little significant changes to the remaining regions on the Earth facing-disc.

Given that AR3947 has been the most active region and will remain on the solar disc for the next four days, the flare risk is being maintained at a steady level throughout this period, pending any further developments.

Overall, activity is forecast to be Moderate to High, with further M-class flares expected and a chance of further isolated X-flares, mainly from AR3947.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	80	80	80	80
Very Active	R3-R5 (X Class)	No	20	20	20	20

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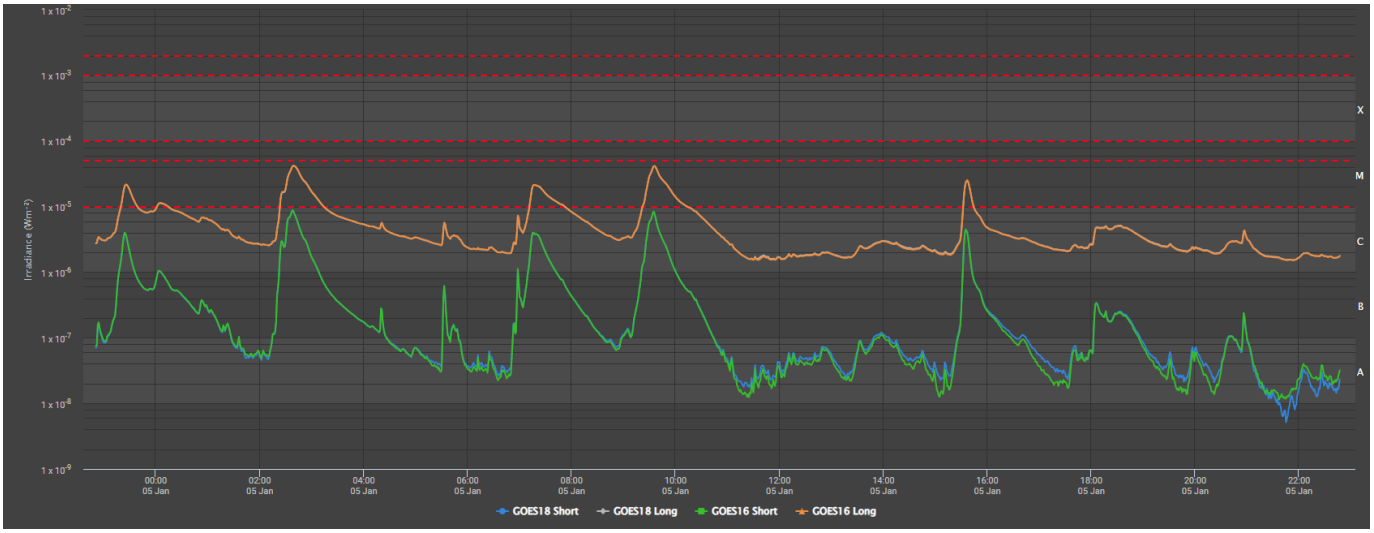
Figure 4: GOES16-18 X-Ray Flux trace.



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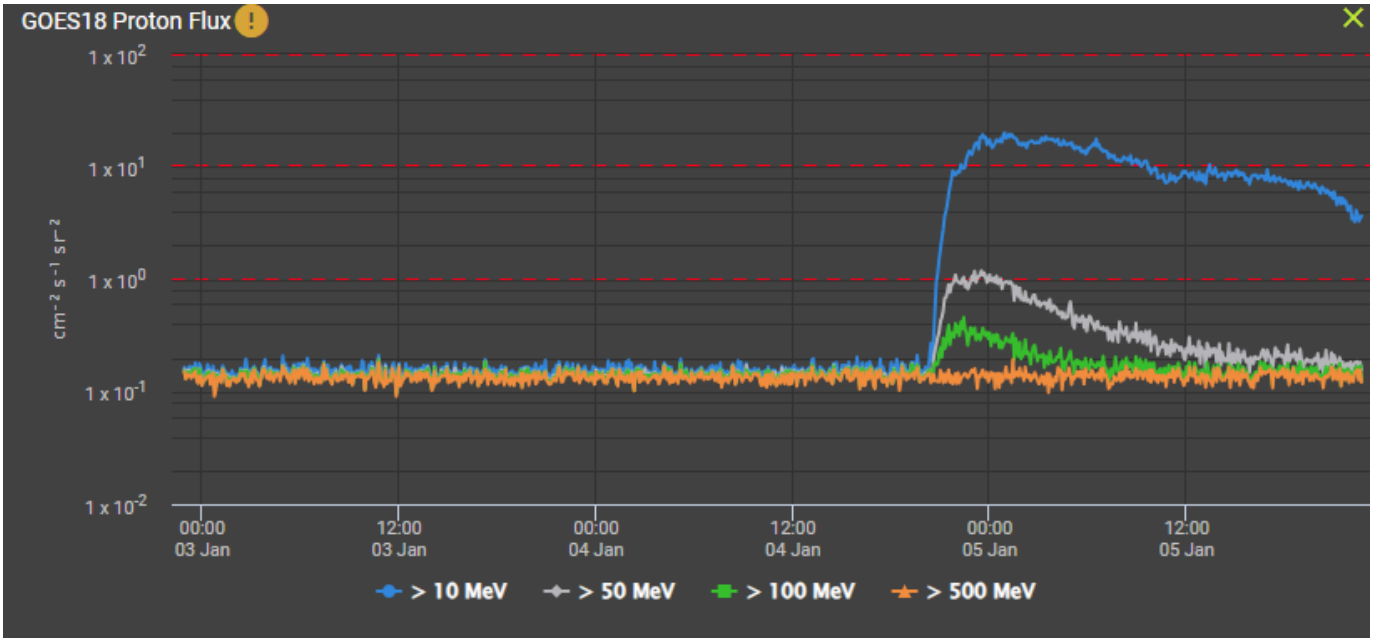
Solar Radiation Storms (High Energy Protons)

GOES18 high energy proton flux has now decreased back below the S1 threshold after recent enhancement. This enhancement came in association with a C9.1 flare from AR3939 in the southwest of the disc. There is a slight chance of further enhancement over the next few days should any further significant flares occur, mainly from AR3939 but also perhaps initially from regions which have now rotated over the western limb.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	20	20	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 5: GOES18 Proton Flux for the past 3-days - shows the rise in 10MeV level (S1 storm) on the 04 Jan.



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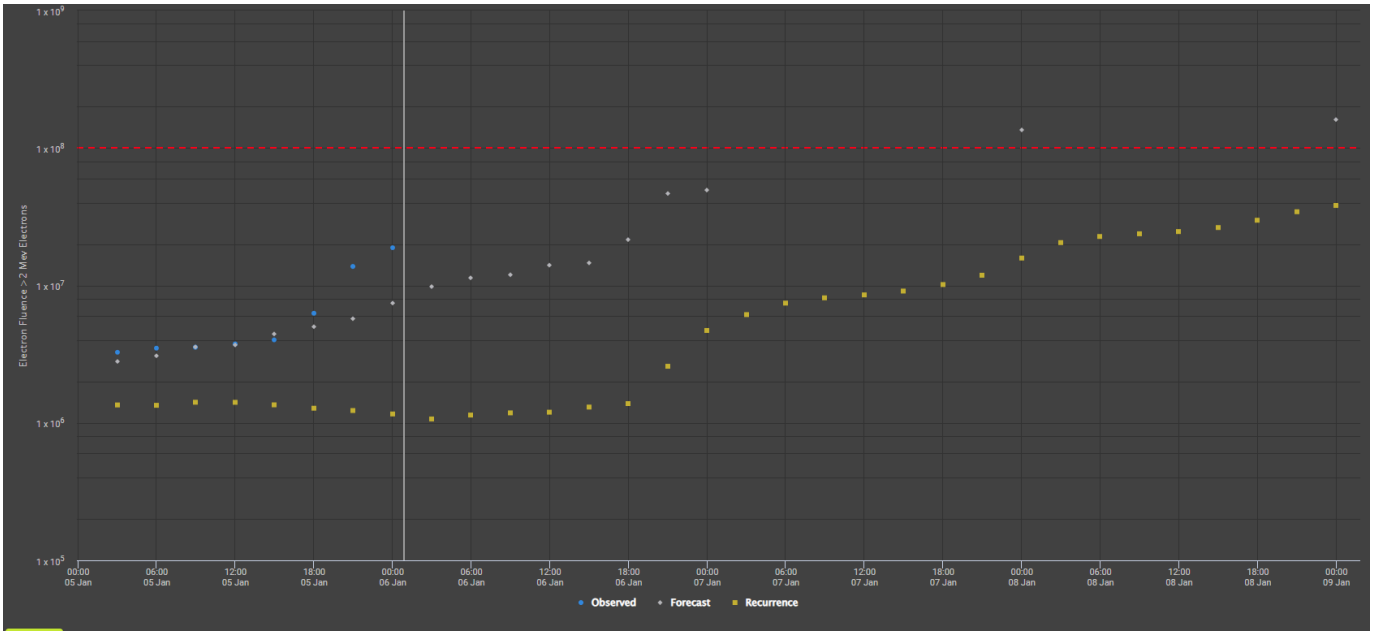
High Energy Electrons (≥ 2MeV)

High energy electron flux observed at GOES16 is currently at moderate to background levels following the connection to the high speed stream from CH05+. This HSS has resulted in strong solar winds, which are expected to continue suppressing the radiation belt away from geostationary orbit (GEO). As a result, electron flux is anticipated to remain at background levels through Days 1-2 (06–07 Jan). However, electron flux may rise to moderate or high levels later in the period as the influence of the HSS begins to wane.

The associated 24-hour fluence is expected to remain below active levels overall. However, due to the potential for rising electron flux levels later in the period, there is a slight chance that fluence could exceed the active threshold, as suggested by MOSWOC REFM.

GEO Electron Environment Probability (Exceedance)	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ 1×10^{8}**	No	1	10	20	20
Very Active	**≥ 2 MeV ≥ 1×10^{9}**	No	1	1	1	1

Figure 6: MOSWOC REFM shows a rising trend later in the period.



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